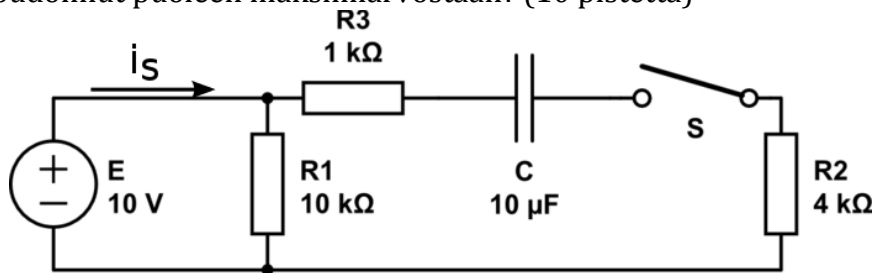


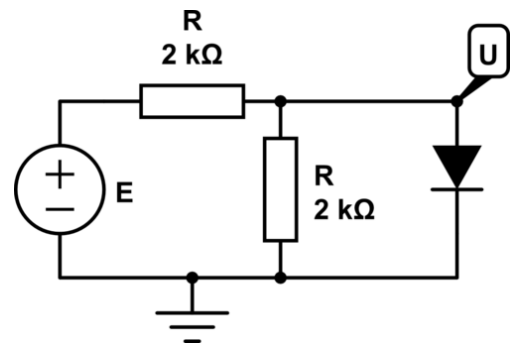
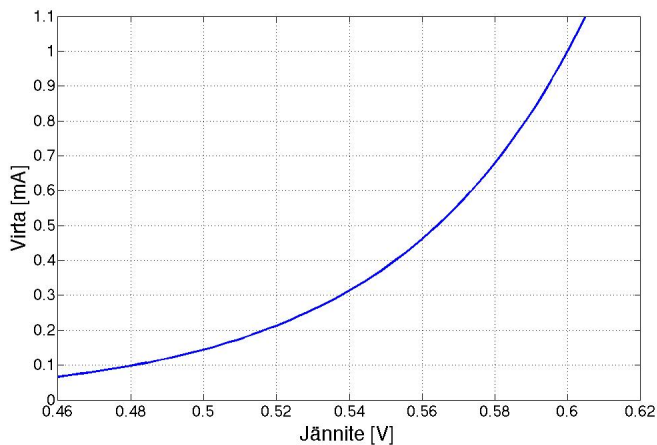
1. Kuvaile lyhyesti

- a. Energia lineaarisissa piirielementeissä: vastuksessa, kondensaattorissa ja kelassa (3 pistettä)
- b. Jännitteen ja virranjako (3 pistettä)
- c. Theveninin ja Nortonin teoreemojen keskinäinen vastaavuus (3 pistettä)

2. Kytkin  $S$  suljetaan ajan hetkellä  $t = 0$ . Kuinka pitkän ajan kuluttua kytkimen sulkemisesta virta  $i_s$  on pudonnut puoleen maksimiarvostaan? (10 pistettä)



3. Kuvassa on osa erään diodin ominaiskäyrästä. Laske diodiyhtälön perusteella lähdejännite  $E$ , kun diodin yli oleva jännite  $U = 0,702 V$ . Diodille pätee  $I(V) = I_S \left( e^{\frac{V}{\eta V_0}} - 1 \right)$ , missä  $\eta$  on vakio, ja  $V_0 = 25mV$ . (10 pistettä)

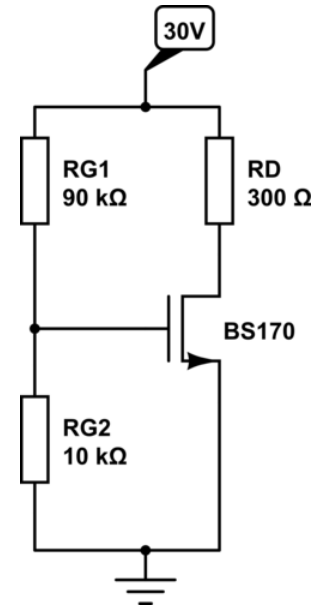


Loppukoe 1.3.2013

vastaa kaikkiin kysymyksiin (yhteensä 48 pistettä)

4. Käytä tarvittaessa apuna liitteen datalehtiä BS170 avauskanava-NMOS transistorille. Käytä tyypillisiä arvoja ("Typ."). Tehtävän transistorille on saturaatioalueella määritetty  $I_D = 16.5 \text{ mA}$ , kun  $V_{GS} = 2.5 \text{ V}$ .

- Hahmottele avauskanava-NMOS transistorin periaatteellinen poikkileikkauskuva, josta selviää transistorin toimintaperiaate. Nimeä eri osat. (3 pistettä)
- BS170-transistorin nieluvirta on asetettu  $I_D = 300 \text{ mA}$ . Mikä on maksimi  $V_{DS}$ -jännite ja miksi? (3 pistettä)
- Kuvan piiri esittää MOSFET:n (BS170) biasointikytkentää, missä toimintapiste on asetettu halutuksi. Määritä toimintapiste ( $V_{DS}$ ,  $I_D$ ). (4 pistettä)



5. Digitaalielektroniikkaa.

- Määritä totuustaulukot NAND, NOR sekä XOR porteille (3 pistettä)
- Tee NAND-operaatio käyttämällä pelkkiä NOR-portteja (3 pistettä)
- Tee OR-operaatio käyttämällä pelkkiä NAND-portteja (3 pistettä)

Mahdollisesti hyödyllisiä yhtälöitä:

$$I_D = K(V_{gs} - V_T)^2$$

$$I_D = I_{DSS} \left(1 - \frac{V_{gs}}{V_P}\right)^2$$

$$i = I_S \left( e^{\frac{eV}{\eta \cdot kT}} - 1 \right)$$

$$V_C = \frac{Q}{C}$$

$$V_L = L \frac{dI}{dt}$$

**Liitteet (1 kpl):**

- BS170 datalehti

# BS170 / MMBF170 N-Channel Enhancement Mode Field Effect Transistor

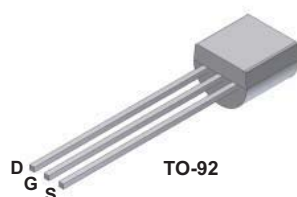
## General Description

These N-Channel enhancement mode field effect transistors are produced using Fairchild's proprietary, high cell density, DMOS technology. These products have been designed to minimize on-state resistance while provide rugged, reliable, and fast switching performance. They can be used in most applications requiring up to 500mA DC. These products are particularly suited for low voltage, low current applications such as small servo motor control, power MOSFET gate drivers, and other switching applications.

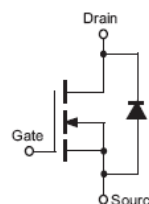
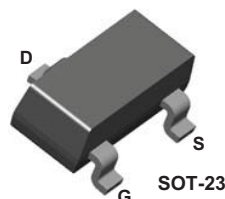
## Features

- High density cell design for low  $R_{DS(ON)}$ .
- Voltage controlled small signal switch.
- Rugged and reliable.
- High saturation current capability.

### BS170



### MMBF170



## Absolute Maximum Ratings $T_A = 25^\circ\text{C}$ unless otherwise noted

Symbol	Parameter	BS170	MMBF170	Units
$V_{DSS}$	Drain-Source Voltage	60		V
$V_{DGR}$	Drain-Gate Voltage ( $R_{GS} \leq 1M\Omega$ )	60		V
$V_{GSS}$	Gate-Source Voltage	$\pm 20$		V
$I_D$	Drain Current - Continuous	500	500	mA
	- Pulsed	1200	800	
$T_J, T_{STG}$	Operating and Storage Temperature Range	- 55 to 150		$^\circ\text{C}$
$T_L$	Maximum Lead Temperature for Soldering Purposes, 1/16" from Case for 10 Seconds	300		$^\circ\text{C}$

## Thermal Characteristics $T_A = 25^\circ\text{C}$ unless otherwise noted

Symbol	Parameter	BS170	MMBF170	Units
$P_D$	Maximum Power Dissipation	830	300	mW
	Derate above $25^\circ\text{C}$	6.6	2.4	mW/ $^\circ\text{C}$
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	150	417	$^\circ\text{C}/\text{W}$

**Electrical Characteristics**  $T_A=25^\circ\text{C}$  unless otherwise noted

Symbol	Parameter	Conditions	Type	Min.	Typ.	Max.	Units
<b>OFF CHARACTERISTICS</b>							
$BV_{DSS}$	Drain-Source Breakdown Voltage	$V_{GS} = 0V, I_D = 100\mu A$	All	60			V
$I_{DSS}$	Zero Gate Voltage Drain Current	$V_{DS} = 25V, V_{GS} = 0V$	All			0.5	$\mu A$
$I_{GSSF}$	Gate - Body Leakage, Forward	$V_{GS} = 15V, V_{DS} = 0V$	All			10	nA
<b>ON CHARACTERISTICS (Notes 1)</b>							
$V_{GS(th)}$	Gate Threshold Voltage	$V_{DS} = V_{GS}, I_D = 1mA$	All	0.8	2.1	3	V
$R_{DS(ON)}$	Static Drain-Source On-Resistance	$V_{GS} = 10V, I_D = 200mA$	All		1.2	5	$\Omega$
$g_{FS}$	Forward Transconductance	$V_{DS} = 10V, I_D = 200mA$	BS170		320		mS
		$V_{DS} \geq 2 V_{DS(on)}, I_D = 200mA$	MMBF170		320		
<b>Dynamic Characteristics</b>							
$C_{iss}$	Input Capacitance	$V_{DS} = 10V, V_{GS} = 0V, f = 1.0MHz$	All		24	40	pF
$C_{oss}$	Output Capacitance		All		17	30	pF
$C_{rSS}$	Reverse Transfer Capacitance		All		7	10	pF
<b>Switching Characteristics (Notes 1)</b>							
$t_{on}$	Turn-On Time	$V_{DD} = 25V, I_D = 200mA, V_{GS} = 10V, R_{GEN} = 25\Omega$	BS170			10	ns
		$V_{DD} = 25V, I_D = 500mA, V_{GS} = 10V, R_{GEN} = 50\Omega$	MMBF170			10	
$t_{off}$	Turn-Off Time	$V_{DD} = 25V, I_D = 200mA, V_{GS} = 10V, R_{GEN} = 25\Omega$	BS170			10	ns
		$V_{DD} = 25V, I_D = 500mA, V_{GS} = 10V, R_{GEN} = 50\Omega$	MMBF170			10	

**Note:**

1. Pulse Test: Pulse Width  $\leq 300\mu s$ , Duty Cycle  $\leq 2.0\%$ .

**Ordering Information**

Part Number	Package	Package Type	Lead Frame	Pin array
BS170	TO-92	BULK	STRAIGHT	D G S
BS170_D26Z	TO-92	Tape and Reel	FORMING	D G S
BS170_D27Z	TO-92	Tape and Reel	FORMING	D G S
BS170_D74Z	TO-92	AMMO	FORMING	D G S
BS170_D75Z	TO-92	AMMO	FORMING	D G S
MMBF170	SOT-23	Tape and Reel		

Typical Electrical Characteristics

BS170 / MMBF170

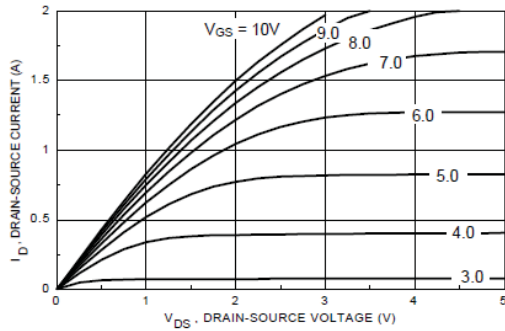


Figure 1. On-Region Characteristics.

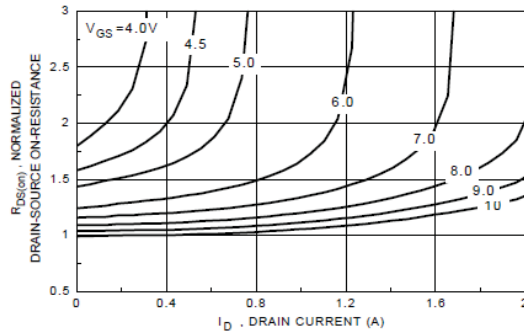


Figure 2. On-Resistance Variation with Gate Voltage and Drain Current.

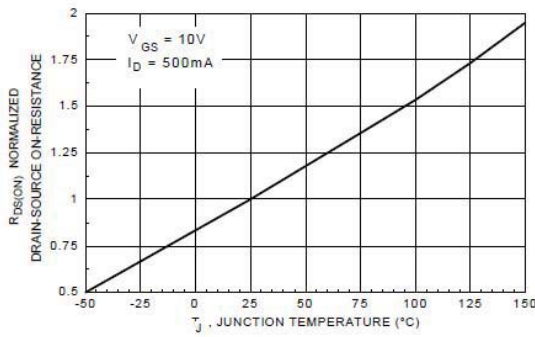


Figure 3. On-Resistance Variation with Temperature.

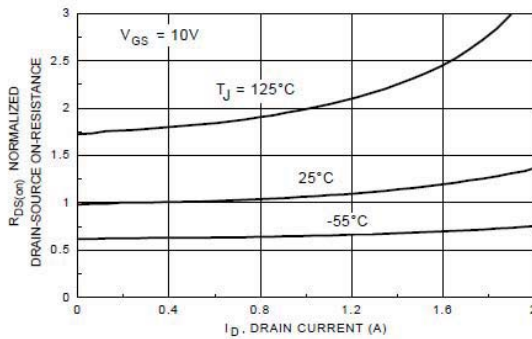


Figure 4. On-Resistance Variation with Drain Current and Temperature.

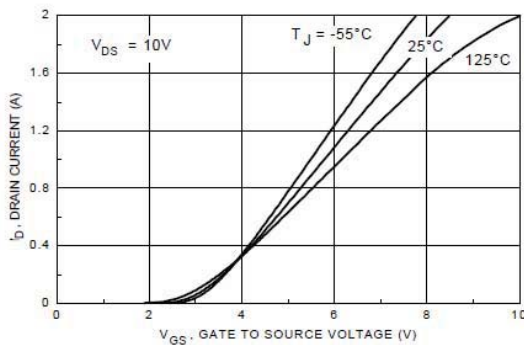


Figure 5. Transfer Characteristics.

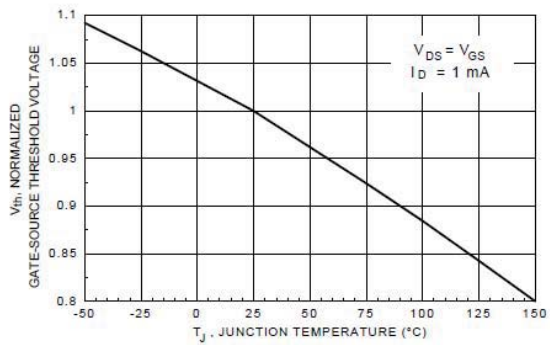
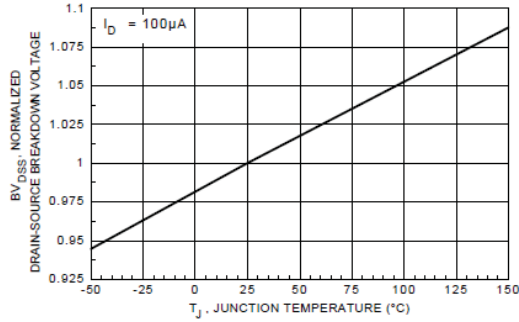


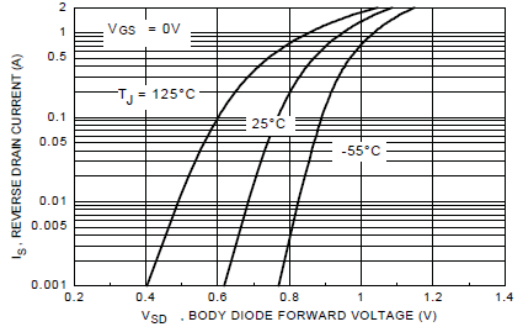
Figure 6. Gate Threshold Variation with Temperature.

**Typical Electrical Characteristics** (continued)

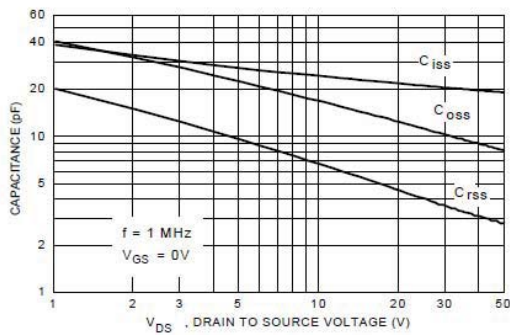
**BS170 / MMBF170**



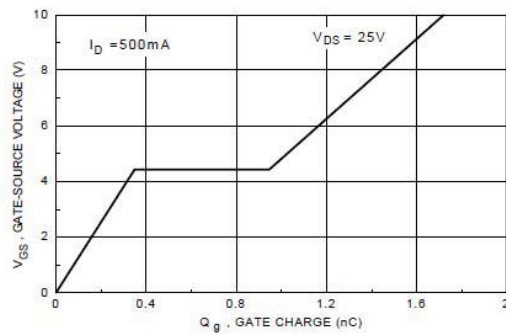
**Figure 7. Breakdown Voltage Variation with Temperature.**



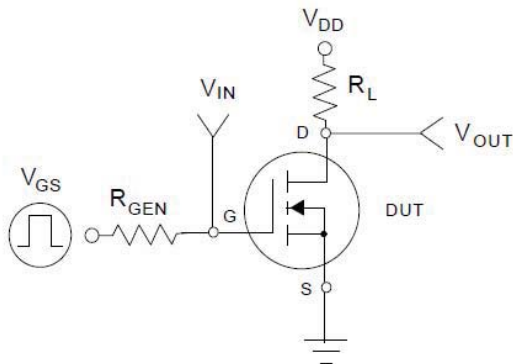
**Figure 8. Body Diode Forward Voltage Variation with Current and Temperature.**



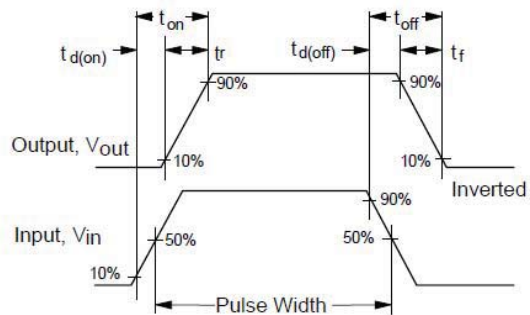
**Figure 9. Capacitance Characteristics.**



**Figure 10. Gate Charge Characteristics.**



**Figure 11. Switching Test Circuit.**



**Figure 12. Switching Waveforms.**